rotational spectral information can be collected using relatively narrow bandwidth OCT probe sources. In addition, coherent detection of Raman signals avoids incoherent fluorescent noise typical of other systems. Although SRS signals have not previously been observed in turbid media, coherent Raman gain spectroscopy has been demonstrated with low-power (including cw) laser sources using nonlinear interferometry.

SRS-SPOCT may be implemented using a modelocked, Q-switched Nd:YAG laser operating at 1060 nm as a pump source and a femtosecond Cr:Forsterite laser with a bandwidth extending from 1250 nm–1350 nm as the SPOCT probe. Assuming SRS gain cross sections typical of organic solvents, modelocked peak pump powers of ~1 MW focused to the OCT probe beam spot size will be sufficient to generate ~1% stimulated Raman gain over a 100 μm window depth in samples. The wavenumber shift available for depth-resolved spectral acquisition with this SRS-SPOCT implementation will encompass 1100–2000 cm^{-1}, including most of the "fingerprint region" used in previous Raman spectroscopy studies of biological media. Many biological molecules have Raman shifts in this range, including proteins with Amide I (1645–1680 cm^{-1}) and Amide III (1225–1300 cm^{-1}) bands which can be used to characterize the α-helix, β pleated sheet and disordered protein conformations, and DNA base vibrations (1100–1700 cm^{-1}) which can be used to differentiate B and Z conformations. SRS-SPOCT can be used to probe the structure of nuclear proteins and DNA, as well as the cytoplasmic and extracellular protein structure in human tissues.

XI. Conclusion

While describing the present invention, we talk about the scanning Michelson interferometer where the reference arm length is mechanically scanned by translating the reference mirror. It is to be understood that the inventions described herein are applicable to any interferometric device which estimates the correlation functions described above. The deconvolution algorithms are also applicable to any device which measures the auto-power spectra and cross-power spectra. Thus, the present invention is applicable to any device capable of measuring any of the above mentioned quantities whether the device operates in free space or is fiber optically integrated. Also, the present invention is equally applicable in situations where a measuring device is coupled to an endoscope or a catheter or any other diagnostic instrument.

The transfer function was described above as a function of spatial frequency (i.e., wavenumber k=2p/l.l is wavelength in the medium). It is to be understood that the transfer function can also be estimated using our methods as a function of optical frequency f'. Note that f' can be related to k by f'=ck/(2p) where c is phase velocity in the medium at that wavenumber. Also, it is obvious that the transfer functions can also be expressed as a function of w=2pf' or k_1=1/l.

Although a low temporal coherence source is useful in making the measurements in OCDR and OCT, it is to be understood that a high temporal coherence source can also be used with the spectroscopy methods of the present invention.

Having described the invention in detail and by reference to the drawings, it will be apparent that modification and variations are possible without departing from the scope of the invention as defined in the following claims.

What is claimed is:

1. A method for determining depth-resolved backscatter characteristics of scatterers within a sample, comprising the steps of:

acquiring a plurality of sets of cross-correlation interferogramn data using an interferometer having a sample arm with the sample in the sample arm, wherein the sample includes a distribution of scatterers therein, and wherein the acquiring step includes the step of altering the distribution of scatterers within the sample with respect to the sample arm for substantially each acquisition; and

averaging, in the Fourier domain, the cross-correlation interferogram data, thereby revealing backscattering characteristics of the scatterers within the sample.

2. The method of claim 1, wherein the averaging, in the Fourier domain, step includes the steps of:

calculating a transfer function for each set of cross-correlation interferogram data acquired; and

squaring the magnitude of each transfer function; and

averaging the squared magnitudes.

3. The method of claim 2, wherein the transfer function calculating step includes the steps of:

acquiring auto-correlation interferogram data for the interferometer;

generating, from the auto-correlation interferogram data, an auto-power spectrum;

generating, from the set of cross-correlation interferogram data, a cross-power spectrum; and

obtaining a ratio of the cross-power spectrum to the auto-power spectrum.

4. The method of claim 1, wherein the step of altering the distribution of scatterers within the sample with respect to the sample arm includes the step of physically altering the distribution of scatterers within the sample.

5. The method of claim 1, wherein the step of altering the distribution of scatterers within the sample with respect to the sample arm includes the step of repositioning the sample arm.

6. The method of claim 1, further comprising the step of comparing the backscattering characteristics with control data to diagnose abnormalities or disease within the sample.

7. The method of claim 6, further comprising the steps of incorporating a sample probe of the interferometer into an endoscope or surgical instrument, and scanning the endoscope or surgical instrument along a portion of a patient's gastrointestinal tract tissue to diagnose abnormalities or disease within the patient's gastrointestinal tract tissue, wherein the control data includes data corresponding to backscattering characteristics of relatively normal gastrointestinal tract tissue.

8. The method of claim 1, wherein the acquiring cross-correlation interferogram data step or the averaging step includes the step of controlling the depth over which cross-correlation interferogram data is averaged.

9. The method of claim 8, wherein the interferometer includes a reference arm and the controlling step includes the step of limiting a scan length of the reference arm to an area of interest in the sample.

10. The method of claim 8, wherein the controlling step includes the step of windowing the cross-correlation interferogram data to an area of interest in the sample.

11. The method of claim 1, wherein the interferometer includes a reference arm and the method further comprises the step of monitoring reference arm path length, wherein the acquisition step includes the step of compensating for velocity fluctuations detected during the monitoring step.

12. The method of claim 1, further comprising the step of directing an intense pump laser to the sample, whereby the revealed backscattering characteristics will contain features

corresponding to inelastic backscattering characteristics of the scatterers within the sample.

13. A method for determining depth-resolved backscatter characteristics of scatterers within a sample, comprising the steps of:

acquiring auto-correlation data from a low-coherence source interferometer, the low-coherence source interferometer including a sample arm;

acquiring multiple cross-correlation data from the low-coherence source interferometer, wherein the low-coherence source interferometer includes a sample in its sample arm;

obtaining an auto-power spectrum for a windowed portion of the auto-correlation data;

obtaining a cross-power spectrum for a windowed portion of each cross-correlation data;

obtaining a transfer function for each cross-correlation data by taking a ratio of the windowed cross-power spectrum to the auto-power spectrum;

squaring each transfer function; and

averaging the magnitude of the squared transfer functions.

14. An optical coherence tomography system comprising:

an interferometer including an optical radiation source and a sample arm, the interferometer generating a plurality of cross-correlation data outputs for a sample in the sample arm; and

a data processing system, operatively coupled to an output of the interferometer, averaging the cross-correlation data outputs, in the Fourier domain, to reveal backscattering characteristics of scatterers within the sample.

15. The optical coherence tomography system of claim 14, further comprising a database containing control data for comparison against the backscattering characteristics of scatterers within the sample.

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